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HL7 standard based Hospital Information System

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Abstract:
The rapid advancement in Information and Communication technology (ICT) in the recent years has spurred the development of Electronic Medical records (EMR) which necessitated the healthcare organization to develop various electronic data interchange (EDI) schemas. It has become almost essential to collect and transfer patient information such as admission details, Lab reports, billing, pharmaceutical details, etc., internal as well as external to the hospital. Currently there is widespread standalone systems such as Hospital Information System (HIS), Laboratory Information System (LIS), Radiology Information System, ADT Information System, EPR, Billing System etc. prevalent in the hospitals are supplied by different vendors requires a common Schema to communicate . The HL7 message format aids here to fill such gap area. In this work we have attempted to develop an integrated HIS, LIS and ADT system by which healthcare professionals and patients can get their Lab reports, prescription details, admission details, appointment verification, surgery scheduling time, etc. in one go. This system also helps the Patients to verify and modify their personal information supplied during the admission in the ADT system. The changes made and the new enrolments are automatically sent to the other relevant information systems. Finally, HL7 standard and Web Enabled HIS improves namely, system interoperability, efficiency and usability which ultimately leads to the benefit of better Hospital administration, the records transfer and maintenance. .

Key words: HIS, LIS, ADT, Medical Information System (MIS), Health Level 7 Trigger Events

INTRODUCTION

The effectiveness of healthcare operations is influenced to the great extent by the automation of information management function. Healthcare institutions and hospitals strive to automate the aspects of their information management in the past two decades. In the first phase, improvement of decision making, reduction of the paper based work process and accelerate the cash flow were the obvious reasons for such striving of these stakeholders.

In the second phase, a paradigm shift in the strategy of automation was noticed in which the stake holders were putting all round efforts to streamline and improve clinical and ancillary services in tandem which included development of bed side and patient side monitors.

In the recent past due to advancement of ICT, researchers have shown curiosity in developing the integrated system governing all the information pertaining to the delivery of healthcare to a patient throughout one's life time in a way of developing electronic records with the capability of communicating them across the world.

It won't be an exaggeration if it is stated today that every medium level hospital have stand alone systems for admissions, billing , accounts maintenance, clinical laboratories, radiology , discharge and transfer etc.. But unfortunately these applications are developed /supplied by different vendors with each having specific formats which make them difficult to integrate.

With the advancement of ICT, the hospitals too began to expand the existing information management system to meet the requirement of sharing the critical data between the systems. Now days few integrated systems developed using centralized or distributed architecture by different vendors are prevalent to cater to many of the health care information management. But however, these systems would not be considered as complete system, provided the same has not followed the external data interchange standards such as HL7 for their production.

HL7 SCOPE

Health Level 7 (HL7) is a US-based, ANSI-accredited health information standards development organisation. It develops specifications mainly for application-level messaging between health information systems, but also in other areas such as clinical documents and decision support [1, 2].

HL7 is a protocol for electronic data exchange among diverse health information systems. It covers areas such as admission, discharge, and transfer (ADT) information; order entry and results reporting, scheduling and referrals; and patient care information [3].

HL7 Message Structure

A basic HL7 message structure flow is shown in Figure 1. HL7 message comprised of groups of segments in a defined sequence. A three-character code contained within each message identifies Message type. The real-world event that initiates an exchange of messages is called a trigger event. There

exists one-to-many relationship between message types and trigger event codes.

A segment is a logical grouping of data fields. Segments of a message may be mandatory or optional. In constructing a message, certain special characters such as segment terminator, the field separator, component separator, subcomponent separator, repetition separator, and escape character are used for clear demarcation of data. The segment terminator is always a carriage return (in ASCII, a hex OD) [4, 5].

In our work an unified Hospital Information System (HIS) integrating Admission Discharge and Transfer (ADT) information system module and Laboratory Information System module (LIS) are developed and integrated with the help of HL7 Standard Version 2.3.1 with the aim of standardizing the practice of electronics record creation and its transfer. Each System is heterogeneous in their function and the database they are handling.

In this work, Microsoft Access is used in the back end to collect enormous data and Java Swing is used as the front end for easy user interface. The remaining part of this paper is organized as follows: Section 2 provides a survey of related works and compares them with the work presented in this paper. Section 3 depicts the architecture of the medical information exchange system proposed and implemented in this work. This section explains the various components of the medical information exchange system. Section 4 explains implementation algorithm. Section 5 shows few results obtained in this work using graphs. Section 6 gives a conclusion on this work and suggests some possible future enhancements.

RELATED WORK

The development of electronic medical record systems was discussed (EMRs) by [6]. Current EMRs are based on earlier PACS systems as well as Hospital Information Systems (HIS) and Radiological Information Systems (RIS). EMR systems of the type described in the paper must be capable of handling a range of information including admission and referral data, images and physiological waveforms.

When used on the form of clinical communications systems they must have the ability to store and retrieve data using different types of databases. Design criteria for EMR systems are discussed, including multi-media presentation.

A web-based validation system implementation providing HL7 messages test services was explained by [7]. This system accepts and parses HL7 messages and warns the errors in segments, sequences, required fields, field length, components, data types and valid values. Besides benefiting to health care organizations, their system may as well provide assistance to student community of medical informatics.

The Hospital Information System focusing on daily operations within hospital to improve efficiency of work by using online clinical data acquisition and processing was developed by [8]. So, to some extent, a HIS improve quality of health care services, but it cannot measure and evaluate the quality of health care services.

At present, hospitals across the world are in a competitive environment and medical tourism is much of talk. In order to attract more patients, high customers' satisfaction is most important for a hospital in the competition. They named their HIS as Hospital Services Management System (HSMS), which is an information system of health care services management in hospital to demonstrate their quality of service with optimum price aimed at highest customers' satisfaction.

Architecture and implementation of heterogeneous medical information system for cooperative environment was proposed by [9]. This architecture addresses all the specific requirements of cooperation in heterogeneous healthcare information system, which uses HL7 medical standard, cooperative work in heterogeneous system and special user interface. It will enable the evolution of innovative healthcare applications and services.

Based on the proposed architecture which includes four layers, medical information have been exchanged using XML and cooperative work in heterogeneous traditional medical systems. In this paper, the architecture have been illustrated using a simple scenario which is cooperative work in HIS and LIS.

The recent information technology would enable operations such as exchanging, standardizing and sharing hospital information through the hierarchical distributed environment. In this work, we present a coordinated multi-layer architecture for HIS based on the Microsoft.net platform. The work outlines some key design principles for a framework for HIS, supporting the development and application of web service-oriented HIS.

SYSTEM ARCHITECTURE

Figure 2 shows the functional block diagram of the current concept visualized in the present work. In this work we have incorporated three heterogeneous information systems namely ADT and LIS are stand-alone application.

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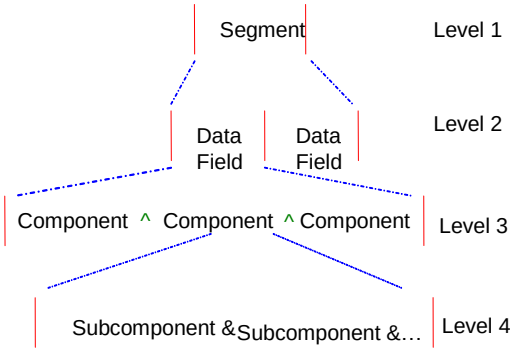

Figure 1 HL7 message structure

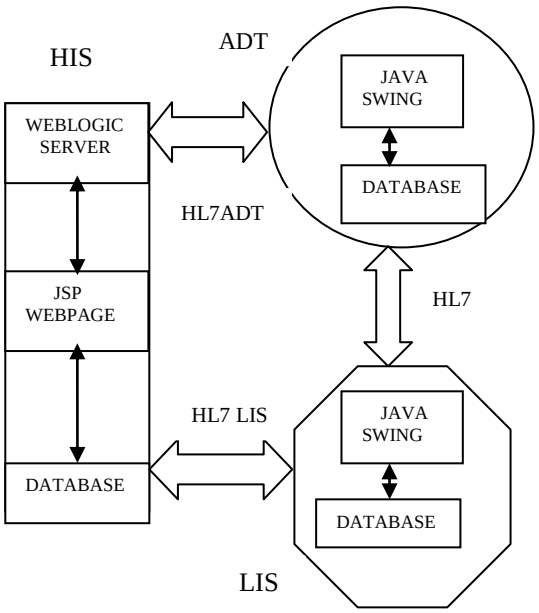

Figure 2: Functional Block Diagram

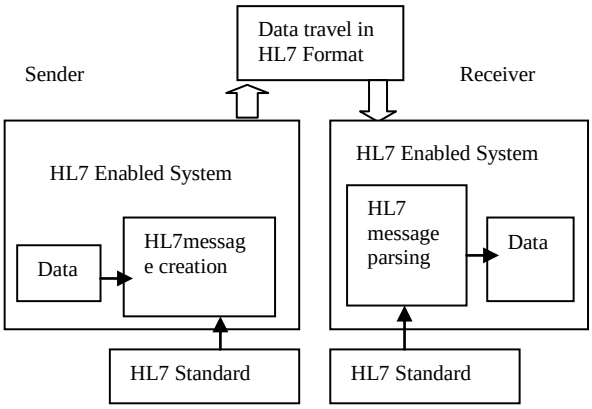

Figure 3.0 HL7 message Transformation

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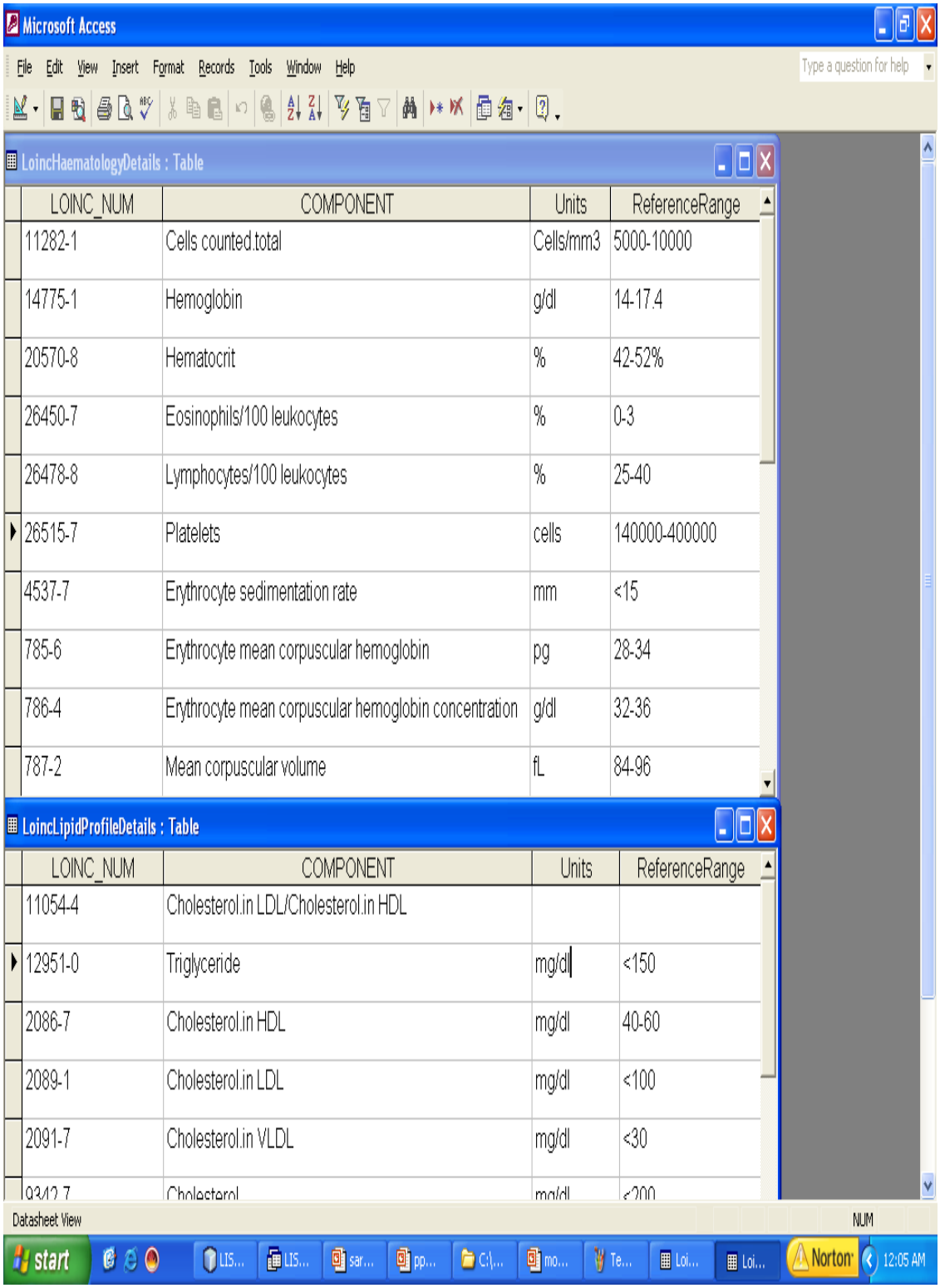

Figure 4.0 LOINC based Test table

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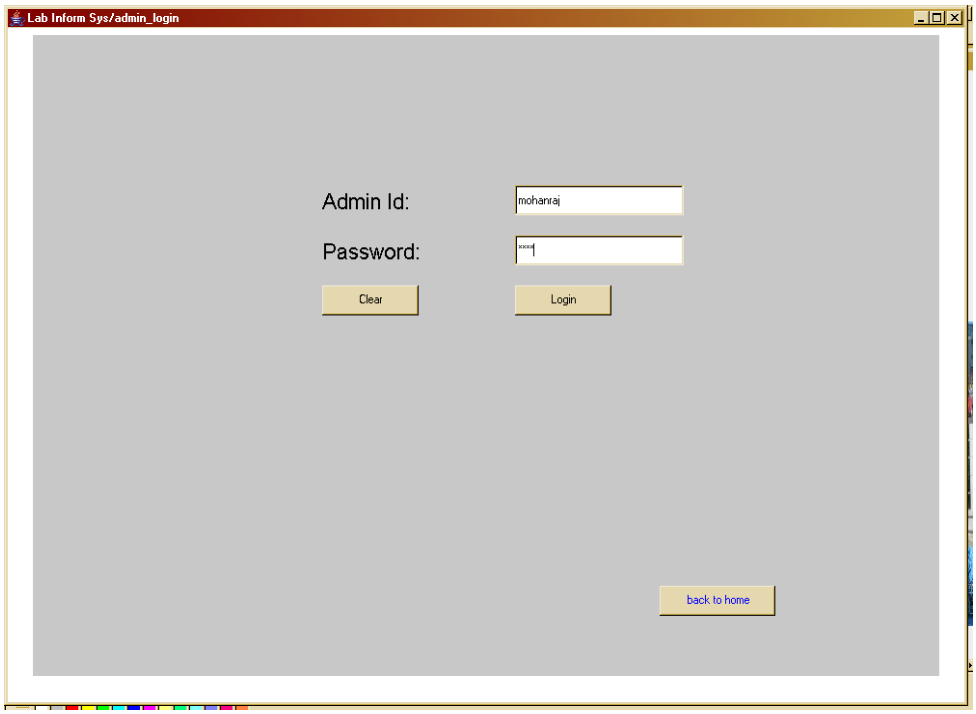

Figure 5.0 Administrator login page

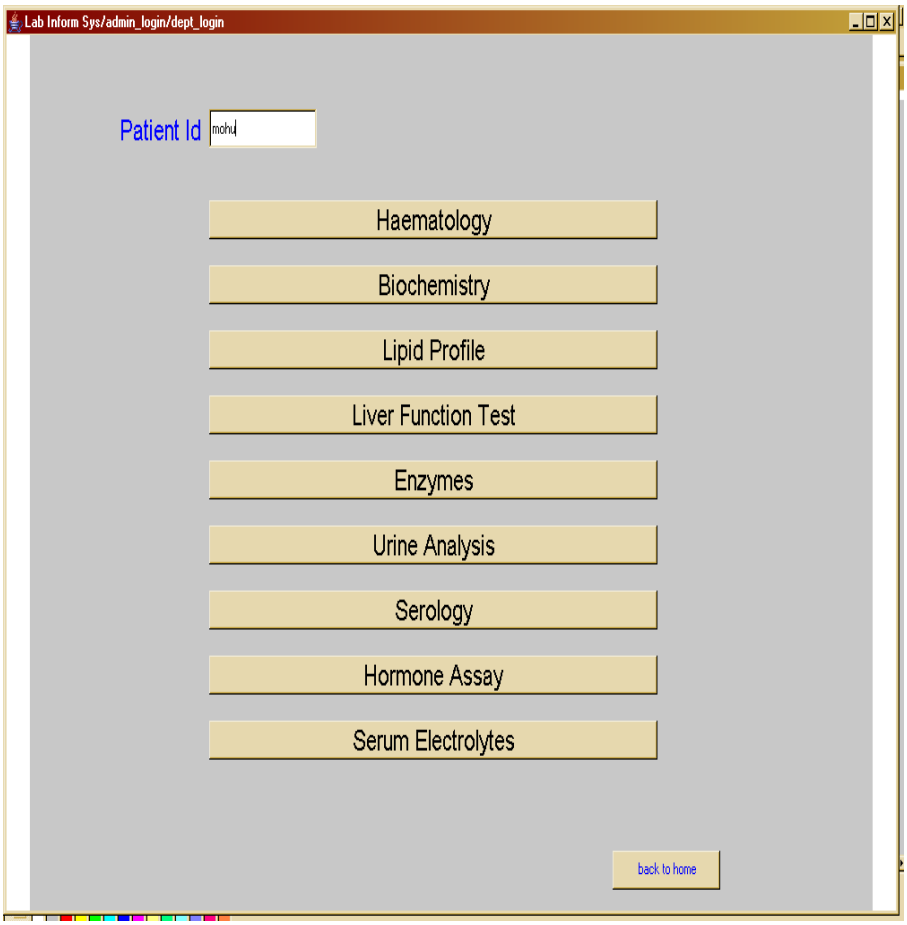

Figure 6.0 Department login page

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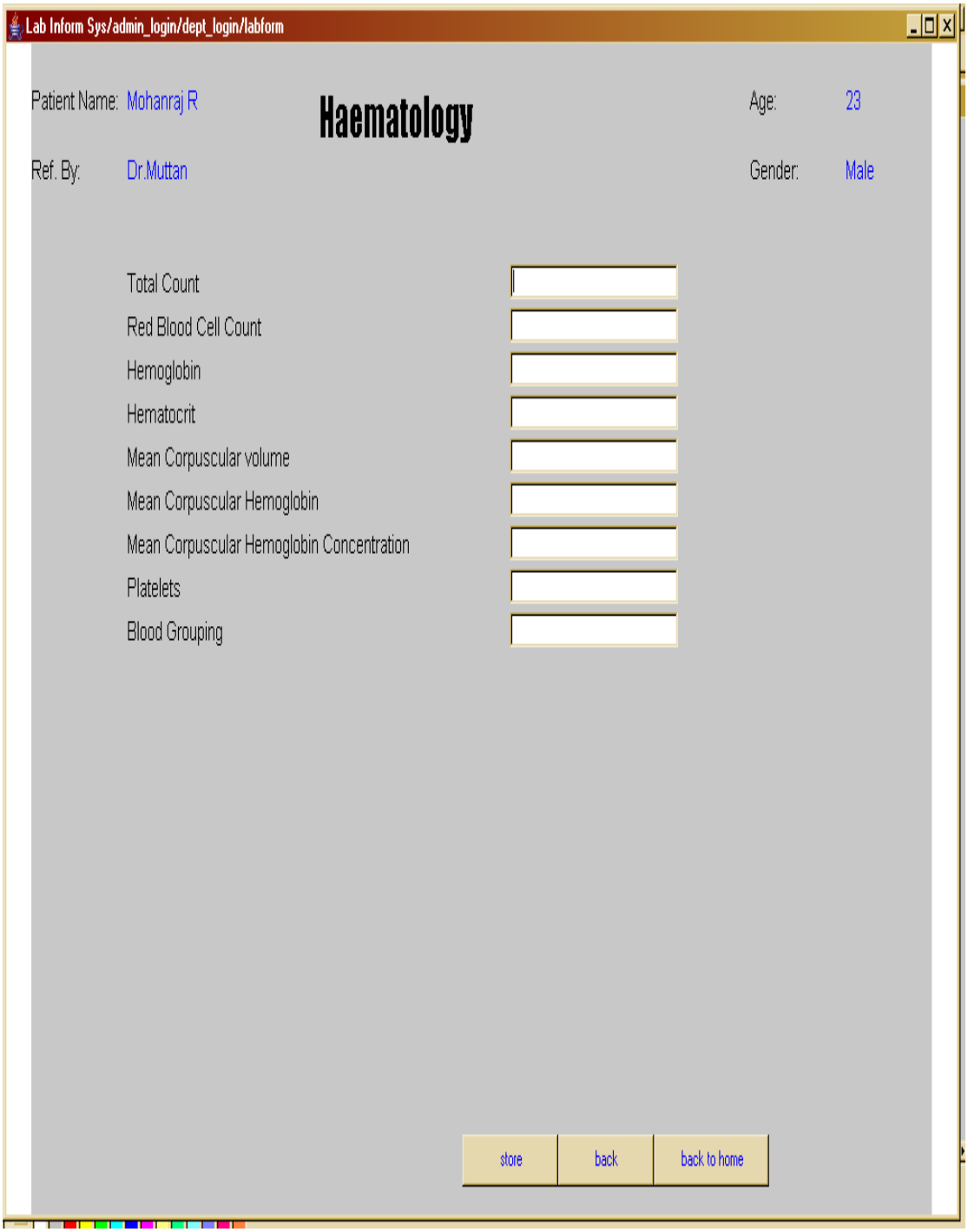

Figure 7.0. Hematology page

Web Enabled HIS

The Web Enabled HIS is mainly to reduce the time of getting appointments and lab reports from the hospital. This HIS provides facilities to verify the information such as their enrollment in the hospital, appointments, lab results, mailing to the doctor. HIS is web enabled system. JSP is used to create the pages for HIS. MS Access is used as Back end. Web logic Server has been used to provide a local server to HIS. Java Message Service (JMS) is used to implement the HL7 message transmission as shown in Figure 3.0. HL7 standard adopts other standards for coding their element name. For example, ISO 3166 provides a list of country codes that is used. Principal language of message Codes come from ISO 639 [4, 10].

ADT INFORMATION

ADT information of inpatient is stored in the ADT database and is sent to other system through HL7 format. ADT information receives patient full referral information while admitting into the hospitals, along with universal ID and this ID used as reference to the

patient information when it transforms to other systems. The ADT system's database developed in the present work consists mainly of four types of tables, they are HL7 Segment values tables, HL7 Segment Details tables, HL7 Message Structure Details tables and HL7/User defined tables. The number of Message Structure tables that are 51. This comprises of 4 fields and contains the Message structure information of the particular event of the ADT System. Segment Details tables contains 8 fields which give the information about each particular segment used in the ADT system. Totally 45 Segment Details tables are created. Segment values tables are used to store the information about the patient at each time the HL7 message transmission occurred. This table contains the fields that are related to the no. of element in that segment. The Front End of the ADT system is designed such that it provides the patient information flow in such an easy manner. The Front office link is used to get the patient details, next of kin details and other admission details. The System will provide the unique id to the patient. The HL7 link is the gateway of the transmission of HL7 message. We can choose the Event of the message, for the each Event, the corresponding segment buttons will appear below, by clicking on the segment button, the segment detail window will appear, and by giving the values here the HL7 message will be formed. Doctors' details are also being fed separately.

LABORATORY INFORMATION SYSTEM

LIS will handle all the Laboratory results of the patient and send it to the other system if necessary. Web Enabled HIS deals online application like appointments, mailing, reports viewing and status of the inpatients.

The patients undergo test in Laboratory and their results will be fed into the LIS, but the patient information will get automatically from the ADT. This Lab results are being sent to the Web Enabled HIS, so that both patient and doctor can access this information through internet. Similarly, LIS uses the LOINC code to identify the laboratory tests [5]; LOINC table contains 50809 component names as shown in Figure 4.0. This system groups the component names under 8 departments namely Hematology, Enzymes, Urine Analysis, Serology, Hormone Assay, Lipid Profile, Liver Analysis test and Serum Electrolytes.

Eight tables are created with details of each department that contains LOINC code, Component Name, Units and Reference range. Similar to ADT system, the LIS also needs HL7 tables. The Front end provides link to test window where test values are noted and stored in the table along with the corresponding patient id. The data collected in this system unsolicited sent to rest of the systems.

PROCESSING ALGORITHM

Step 1: The initiating system constructs an HL7 message from application data and sends it to the responding system as shown in Figure 4.0.

Step 2: Responder receives message and validates the message syntactically and against the detailed rules. If it fails,

a) reject message is constructed by the protocol software and returned to the initiator; If it does not fail, continue to the next step.
b) passes the message to the application, which:
   1. Creates a response message, or
   2. Creates an error message, or
   3. Creates a reject message

c). sends the response, error, or reject message

Figure 5.0 show the administrator login page of the medical information system for updating, and maintenance purpose. The admin will restrict the user rights. The authorized user who is either service personnel of the healthcare organization or the customer or patient can enter in to the pages to achieve their needs as shown in Figure 6.0. The patients lab results from hematology department is uploaded with patient information and physician information as shown in Figure 7.0

RESULTS

Upon relevant data entry by the authorized user the data gets converted into HL format by the ADT module. The corresponding HL 7 message as given below generated during the Patient Admission Event A01. It conveys that Patient KAVIN JOSEPH was admitted on Sep 14, 2011 at 10:45 a.m. by Doctor Sidney J. Lebauer for surgery (SUR). He has been assigned to room 305, bed 07 on Block D. The message was sent from system ADTSYS to LIS. Likewise the other heterogeneous systems also designed to convert the data into HL7 format which makes easy transfer of data to the external world in a standard and secured manner.

MSH|^~\&|ADTSYS||LIS||201109191226||ADT
^A01|MSG00002|P|2.3.1|<cr>
EVN|A01|201109141045||<cr>
PID|1||PATID1254^4^M12^ADT1^MR^MCM~
123456789^^^IN^SS||KAVIN ^JOSEPH ||19610615|M||C|1200 N ELM
STREET^^GREENSBORO^NC^27401-1020|G
L|(919)379-1212|(919)271-3434||S||PATID1254
001^2^M10^ADT1^AN^A|123456789|9
87654^NC|<cr>
NK1|1|AANI ^KAVIN ^K|WI^WIFE||||NK^
NEXT OF KIN<cr>
PV1|1|I|BLKD^305^07|||004777^GUIND ^
CHENN^J.|||SUR||||ADM|A0|<cr>

The Query Message shown below has been generated by HIS and is being transferred to LIS. Query for all

lab results on patient #1254. The query is made at 11:00 a.m., 9/02/2011. The Query anticipates an immediate display-oriented response.

MSH|^~\&|HIS||LIS||||QRY^Q01|MSG0001|P|2.3<cr>QRD|201109021100|D|I|47|||20^LI|133|RES|ALL<cr

The response Message to HIS has been generated by LIS that is shown below.

MSH|^~\&|LABSYS||HIS|||DSR|ZXT23469|P|2.1<cr>
MSA|AA|MSG00003|<cr>

QRD|201109021100|D|I|87|||20^LI|133|RES|ALL<cr>DSP|||RESULTS FOR PATIENT#1254 KAVIN, JOSEPH. 09/02/11<cr>
DSP|||SPECIMEN COLLECTED 09/10/87 07/0/0<cr>
DSP<cr>

DSP|||ELECTROLYTES<cr>

DSP||SODIUM 137 [134-149] MEQ/L STAT<cr>

DSP|||POTASSIUM 4.5[3.5-5.0]MEQ/LSTAT<cr>

DSP|||CHLORIDE 89[95-111]MEQ/L STAT<cr>

DSP||||LB<cr>

DISCUSSION AND CONCLUSION

The information system is fully governed by HL7, so information handled in the systems are based on the HL7 segment values. For usability purpose, the test names window is developed in LIS directly reflects the department name and in ADT system color difference is used in the creation of HL7 messages. Also, LIS uses the LOINC code to identify the laboratory tests and LOINC table contains 50809 component names. Message transfer functionality is developed through Java Message Service (JMS). Besides supporting the electronic medical record data interchange, the medical informatics student's community can use the system developed as learning tool to understand and get familiar with the HL7 standard. Our future goal is to implement the XML data exchange format into an I/O interface and to upgrade this system complying with HL7 version 3.0 standards.

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